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COSMIC RADIATIONS AND ASTRONOMICAL RESEARCH

By LACHLAN GILCHRIST

(Annual Address of the President, February 4, 1936)

PROBLEMS which are associated with phenomena produced in a laboratory by an investigator admit in general of methods of attack from so many angles in the effort to obtain their solution that an extensive body of correlated evidence on the character of the phenomena may be gathered. Quantitative measurements may be made on the forces, momenta and energies involved and on the properties made manifest to the observer. Even the character of the phenomena may be modified at will. Interrelationships may be established with a wide range of experimental results from allied fields of investigation, by wholly independent observers and methods of attack. Further, the workers have at times at least a feeling of being at close grips with the problem even though with the increasing body of information the solution appears to become more elusive or confused by a multiplicity of new problems crowding on the horizon. The comprehensiveness of the investigation is such, however, as to inspire confidence in the presentation of tentative solutions of the primary problem or in the prediction of the existence of new problems awaiting investigation.

In comparison the investigation of astronomical phenomena is limited indeed. One yearns perhaps for direct close contact with the associated problems such as is possible in laboratory investigations. For example, one would like to visit the planets in order to speak

with more confidence about their inhabitability. There are those who in a hopeful mood attempt to devise ways of sending messages to Mars which even on the merest chance may be correlated with some longed-for return message. Even that brilliantly productive astronomer and philosopher, Professor Henry Norris Russell of Princeton University, in the *Scientific American* for December, 1934, attempts to determine the most advantageous conditions under which a missile may be made to leave the earth with the minimum initial velocity and describe a path close to the planet Mars. Perhaps there is the unexpressed hope that since also there are suitable conditions, however difficult to realize, under which the missile would find a place on Mars and would stimulate possibly a message in return, one might even dare to hope that Professor Russell would determine the path of a missile sent from the earth in the most advantageous direction such that with the minimum initial velocity and having regard to the gravitational fields and atmospheric resistances which it would encounter, it would pass around another planet, e.g. Mars, and possibly return to the earth. Then of course there would be the further hope that the path might be sufficiently close to Mars that the necessary conditions for making a complete journey could be provided and that with a suitably arranged automatic camera one might obtain *direct* evidence of the existence on Mars of life such as we know it on the earth, or perhaps in some other form of life at present inexperienced and unimagined by the inhabitants of the earth. One would hope also that the necessary conditions might be possible of provision and thus stimulate investigation to set out on another great adventure in astronomical research.

Such direct contacts with the objects under investigation have not yet been made and all information of the conditions which are associated with our own solar system, with the single exception of meteorites, or with members of our own galaxy or of neighbouring or remote galaxies must be obtained by a study of the properties and effects of radiations emitted by these members acting as primary or secondary sources and the correlation of these with the results of investigations on similar radiations from laboratory sources. The former are correctly designated cosmic radiations. They vary widely in character and may be classified for convenience as follows:

1. Infra-red rays whose spectra extend in wavelength from heat rays of long wavelength undetectable by the eye to rays of wavelength seven ten-thousandths of a millimeter, which, on entering the eye of the observer, produce a red sensation. The existence of these infra-red rays must necessarily be inferred indirectly from their effects on such detecting devices as photographic plates, thermocouples, etc.

2. Visible light rays of still shorter wavelength from about seven to four ten-thousandths of a millimeter which produce on the observer colour sensations red, orange, yellow, green, blue and violet, and from these sensations the existence of these rays is directly established. There are, of course, also several indirect means of detection of these rays similar to those for the infra-red rays.

3. Ultra-violet rays of still shorter wavelength down to one ten-thousandth of a millimeter. The existence of these rays is also indirectly inferred from photographic, photoelectric and ionizing effects.

4. Very penetrating rays to which has been given the name Cosmic Rays which have been considered by some investigators as rays of extremely short wavelength ranging down to one ten-millionth of a mm in wavelength or by others as charged particles approaching the earth with speeds of 10^9 to 10^{10} cm per second. The existence and character of these rays is inferred from their penetrating power, their ionizing capability and their action in strong magnetic fields.

The first three of these classes of radiation are definitely oscillatory in character differing in frequency of oscillation but with the same velocity of propagation in free space and therefore differing in wavelengths. Their properties are similar but these properties are not uniformly prominent. The distribution of energy in spectra of the radiation from various sources varies widely. From some sources, e.g., the sun or hot stars, the spectrum is so extensive that investigations may be made over a wide range of wavelengths while from many stellar sources the radiation is confined to the infra-red or to a narrow range in the red end of the visible spectrum. The spectra may be continuous over a wide range (which is the indication of an incandescent solid or liquid source) or contain more or less narrow bright emission lines which indicate the existence of an incandescent

gaseous source or dark absorption lines which indicate an enveloping gas. A correlation of these spectra with similar spectra of the radiations obtained from laboratory sources enables the observer to determine mass, temperature, density, atmosphere and motions of the sun and planets, and of individual stars or of galaxies as a whole. The properties of the fourth class, the cosmic rays, have been under intensive investigation in recent years and much information as to their character has been gathered, but theories of their origin based on their properties are at present indefinite and highly speculative.

The first three classes of these radiations have been used extensively to obtain information on currently existing conditions on members of our solar system and owing to their speed of propagation, viz. 186,000 miles per second, to obtain some knowledge of the conditions existing even on the confines of the solar system a few hours previous to the observations; but of the nearest star we can only get information that is four and one-third years late in reaching us and it should be noted that the information which reaches us from the nearest stars on the outer edge of our galaxy is of conditions that existed at least 16,000 years ago, and still more remarkable the information we are receiving to-day from the most remote neighbouring nebular galaxy, one located during the past year by Professor Shapley of Harvard, is of conditions that existed five hundred millions of years ago. Further, this galaxy was then receding from us with a velocity of 50,000 miles per sec., i.e. greater than one quarter of the speed of light itself.

The distance 500 million light years is deduced from the apparent intensity of the nebula obtained photometrically and its absolute intensity or magnitude from characteristics of its spectrum. The recession speed, 50,000 miles per second, is determined by a measurement of the Doppler effect as exhibited in its spectral lines. It is observed that in general the greater the Doppler effect and therefore the faster the recession, the more distant is the nebula, which acts as a check on the former deduction of distance. Moreover the phenomenon suggests an expanding universe. The enormous values for the distance and for the speed of recession give rise to misgivings as to their reality. It will be noted that the recession speeds are of the order of speeds found for electrons in electrical discharge in gases

and one wonders if the calculation of these speeds from the Doppler shift of the lines is permissible. The Doppler formula which is made use of needs redevelopment. It is certainly not valid for speeds approaching the velocity of light. Perhaps also it would be well to repeat the Doppler shift measurements on radiations from fast-moving sources such as proton or electron disturbances. Moreover, since the wavelength of the equivalent photon radiation may be measured from the diffraction spectra produced by charged corpuscles it would probably be desirable to determine the values of the deduced wavelength over a considerable range of speed of the corpuscles.

The beginnings of systematic astronomical observation and interpretation may possibly be placed with the Egyptian priests and pyramid builders about 4,000 years before the beginning of the Christian era but probably much more precisely with the Grecian philosopher Hipparchus 160 B.C.—125 B.C. It will be recognized then that the information we are now receiving from stars that are 6,000 light years distant is of conditions that existed on those stars at the dawn of astronomical investigation. Since our galaxy has a population of one hundred billion and the number of galaxies from which we have information is legion, and the information at hand is very meagre indeed, therefore pronouncements of the conditions existing at the present moment outside of our own solar system are speculative indeed. With even meagre information we are able to interpret and explain on general principles with a degree of sufficiency depending on the extent and accuracy of our information, but we are never able to demonstrate the absolute necessity or uniqueness of our interpretation. Moreover since information from the galaxies is meagre and indefinite a rapid succession of widely differing interpretations has been presented which gives rise to a realization of the unavailing character of the many speculations with regard to the distant members of the universe or of the character and size of the universe as a whole.

The use of these radiations in astronomical research during the year 1935 has been so extensive that adequate consideration of the results is precluded. Only a few examples will, therefore, be presented.

I. The Existence of an Element Nebulium.

In the emission spectra of the radiation from diffuse and planetary nebulae there are certain lines whose wavelengths did not coincide with those of any lines found in the spectra of the radiation from any known source. They were supposed to indicate the existence of an element in the nebulae which did not exist on the earth. This element was called Nebulium.

Now the spectral lines and bands in the radiation from any element have been organized into series with a simple systematic numerical relationship between the components of the series and the characteristics of the series have afforded much evidence on the atomic structure of the elements and on the interrelationships of the elements. In this work the series of spectral lines of the light from the primary element hydrogen has been of primary and special significance. There are five series of lines, three of which have been recognized in stellar spectra. The Lyman, or ultra violet series, the Balmer or visible spectral series, and the Paschen, Brackett and Pfund or infra-red series. Their characteristics are definite and their numerical relationships are simple. The development of quantum mechanics has made it possible to determine the energy states associated with the production of the component lines in the spectrum from the structure and relative intensities of the lines. Moreover it is shown that conclusions may be drawn concerning the physical conditions in the source necessary for the production of the component lines. Further, conditions exist under which in the spectrum of radiation from terrestrial sources certain lines are absent or "forbidden" while they are present in stellar sources.

Now Professor I. S. Bowen of the California Institute of Technology has shown that the formerly mysterious Nebulium spectral lines are radiations from common elements which are emitted under conditions of excitation that do not exist on the earth and he has determined the probable mechanism of their production. The following abstract is presented with Professor Bowen's paper in the *Astrophysical Journal* for June, 1935:

Abstract

I. The primary source of nebular luminosity is the emission on the return

of electrons after ionization by extreme ultra-violet starlight. Additional luminosity is produced by the following secondary mechanisms:

(1) Ionization by secondary radiation.—Additional atoms are ionized by extreme ultra-violet quanta emitted by the primary mechanism.

(2) Excitation by secondary radiation.—Line absorption of secondary quanta may excite an atom of the same kind as the primary emitting atom, or any other atom that has absorption lines which coincide with lines of the emitting atom. This mechanism, made possible by certain chance coincidences between lines of He II, O III, and N III, explains the presence with a high intensity of a selected group of O III and N III lines while all other lines of these elements are missing.

(3) Excitation by secondary electrons ejected by the primary mechanism.—This is practically the sole source of excitation of the forbidden lines.

II. A study of nebular line intensities in the light of the foregoing processes indicates that H is the most abundant element and He is the second. N, O, Ne, S—and possibly C and A—are present but are very much rarer. The lines of these heavier elements are strong, not because the elements are very abundant but because they are able to make use of large sources of energy that are not available to the predominant H and He. Lines of F, Na, Si, P, Cl, K, and Ca are missing.

II. Investigations on the Binary Star Zeta Aurigae.

In 1842 Doppler enunciated the principle that light from a source in motion relative to the observer should show a change in colour of a luminous body, and Fizeau, in 1848, suggested the use of this shift of the lines in its spectrum to determine the radial velocity of a star. For a source approaching the observer the spectral lines should be shifted towards the violet end of the spectrum and for a receding source the shift should be towards the red end of the spectrum. The existence of the changing Doppler shift in the spectral lines in the radiation from Zeta Aurigae indicates the binary character of the source. From measurements of the Doppler shift and a study of the characteristics of the spectral lines very interesting information has been obtained which distinguishes this double star from all others so far discovered.

(a) The star is a close double with the components of very different temperatures. One component is a red star with red light predominant and showing dark spectral lines. The other is apparently a hot star showing the characteristic wide hydrogen lines in the green and blue.

(b) In 1924 Harper at the Dominion Astrophysical Observatory in Victoria, determined the period of the red star as 972.4 days and discovered the periodic eclipsing of the hot star by the red component. In 1932 Guthnick and Schneller found that the eclipse lasted for three weeks.

(c) Investigations of the eclipse which extended from August 24th to October 1st last provided information to many observers, as follows:

(1) The red star is at least 40 times the diameter of the white one.

(2) In the yellow and green region the large star is about four times as bright as the smaller star but since the latter is so small it actually gives out much more yellow light per square mile than the large red star. The spectrum of the latter star indicates a temperature of about 2,300 degrees while the temperature of the small star is about 15,000 degrees.

(3) The average separation of the components is 530 million miles, ranging from 310 million miles to 750 million miles. The diameter of the large star is about 200 times that of our sun. The diameter of the smaller star is about 1/50 of this.

(4) The small star is 8 times as massive as the sun and its density 1/3 to 1/8 of the density of the sun. The large star is 16 times the mass of the sun but because of its large volume its density is about 1/500,000 of the density of the sun.

(5) The red star emits about 1,000 times and the small star about 200-300 times the light emitted by the sun.

(6) The distance of the white star indicated by its size and light emission is about 750 light years.

III. Investigations on Nova Herculis.

This is the fifth very bright nova to be observed since the beginning of the century and only three such were discovered in the last century. It was first seen as a star of the fifth magnitude on December 14th by an English lawyer, Mr. Prentice, who is also an amateur astronomer and a member of the British Astronomical Association, in the course of meteor observation. It was located in northeastern part of the constellation Hercules about 10 degrees northwest of the

bright star Vega and between it and the head of Draco. It had escaped observation in the routine visual or photographic search of the sky for new objects usually made regularly at some observatories. A subsequent examination of photographic plates shows its existence on October 4th and for 40 years previously as a star of magnitude 14.5, and on November 14th as a star of magnitude 13 and about the 23rd of December it had reached its maximum brightness of a star of magnitude 1.5. It was the object of intensive study at many observatories. The work done at the Solar Physics Observatory at Cambridge, England, on Neutral Oxygen and Carbon in Nova Herculis 1934 by Professor F. J. M. Stratton and Dr. Arthur Beer published in the *Monthly Notices* of the R.A.S. for March, 1935, and on the Light-Curve and the Visual Spectrum of Nova Herculis, 1934, by Dr. Arthur Beer published in the *Monthly Notices* for April, 1935, presents some of the information that has been obtained and may be summarized.

First paper.

(1) Many lines of Neutral Oxygen and of Neutral Carbon were identified in the spectrum of Nova Herculis.

(2) Three forbidden lines of Oxygen I, viz. 5577, 6300, and 6364 A.U., respectively, were identified as emission bands in the spectrum.

(3) There was no evidence for the existence of Nitrogen I in the spectrum range H to K largely the range of the visible spectrum.

The existence of the band 5577 in the spectrum of Nova Herculis is very interesting. This band is identical with the green auroral line or narrow band whose origin was ascribed to solid Nitrogen by Vegard and Kaplan and to Helium by Professor McLennan and later to Oxygen by Professor McLennan and Dr. Shrum in the presence of helium and argon. It is of interest to note that Joseph Kaplan is now able to produce this line as an oxygen line excited in the presence of a small amount of nitrogen.

Second paper.

(1) A light-curve of Nova Herculis from December 13th, 1934, to April 27th, 1935, based on 4,562 observations from various sources is presented.

(2) A detailed record is presented of the lines and bands which appeared in the spectrum during the period December 13, 1934, to April 27, 1935, and of their changes in intensity.

(3) From (1) and (2) it is hoped to determine the "life history" of the Nova as it "swells up and bursts" in order possibly that its past may be described and its future predicted or that the information obtained during the rapid changes may be correlated with that obtained on slowly changing stars.

A similar provisional light-curve was also constructed at the Harvard College Observatory from a total of 2,017 observations by 170 different observers and is presented by Leon Campbell in the Harvard College Observatory Bulletin No. 898, March 1st, 1935.

The distance away of Nova Herculis has been calculated by Dr. Struve of Yerkes Observatory as 1,500 light years from the intensity of the K line of Calcium. This indicates that its maximum brightness is about 40,000 times the sun.

Further, both bright and dark lines appeared in the spectrum with definite Doppler displacements, indicating incandescent ebullitions following behind cooler clouds, at speeds averaging nearly 200 miles per second, and travelling long enough to reach distances of 500,000,000 miles.

IV. Investigations on the Sun.

(1) *The existence of elements in the sun.*

The existence in the stars and in the sun and planets and in their atmospheres of many of the elements which are found on the earth is fairly well established. The evidence depends on the identification of the emission and absorption spectral lines which are produced when these elements are made to emit radiations in a laboratory with the emission and absorption spectral lines found in stellar, solar and planetary sources. Of the 92 elements existing on the earth there are now 59 known to exist in the sun. Phosphorus is the last to be so identified. This has been done by Dr. Charlotte E. Moore of Princeton University from solar spectral photographs made by Dr. Harold D. Babcock of Mount Wilson Observatory and spectral plates of the radiation emitted by a phosphorus source made by Dr. C. C. Kiess of the U.S. Bureau of Standards.

(2) *Spectrum of the Corona without an Eclipse.*

Hitherto spectroscopic investigations on the chromosphere of the sun have been effectively carried out when the light from the sun's disc is screened off by a total solar eclipse. Harold D. Babcock and Horace W. Babcock at Mount Wilson Observatory have succeeded in identifying hydrogen and helium lines and notably the green auroral line 5577.35A and the red coronal line 6374.28A in spectra of the chromosphere taken without an eclipse.

(3) *Solar Magnetism.*

In 1895 Zeeman had shown that the spectrum lines of luminous metallic vapours between the poles of a magnet are widened or split into several components polarized in distinctive ways. Over 50 years before this Faraday had suspected such an effect but was unsuccessful in obtaining it experimentally. In 1908 Hale and Mitchell established the fact that spectrum lines of the light from sun spots were widened or even separated into doublets or triplets and it soon became evident that there were magnetic fields in the sun spots much like the magnetic fields which Professor Zeeman used in his laboratory at Amsterdam. The results of investigations on the progressive changes in sun spots and their magnetic properties since 1908 may be summarized:

(a) The spots exist in pairs, one representing the N-seeking and the other the S-seeking pole.

(b) The pairs of poles are usually located at greater or less intervals, side by side, parallel to the sun's equator.

(c) Sun spots of a new 11.2-year cycle which appear in high latitudes after a minimum of solar activity are of opposite polarities in the northern and southern hemispheres, and as the cycle progresses the mean latitude of the spots in each hemisphere steadily decreases but their polarity remains unchanged. Further, the high latitude spots of the next 11.2-year cycle appear during the last year of the first cycle and gradually increase in intensity and diminish in latitude but are of reversed magnetic polarity, i.e., there is a full spot-period with reference to magnetic polarity of about 23 years.

These changes are graphically presented in a diagram accompanying a paper presented by Dr. George E. Hale in *Nature* for November 2nd, 1935, in celebration of the seventieth birthday of Professor

Zeeman. In this paper Dr. Hale also presents the evidence in support of the notion that the sun as a whole acts as a weak magnet having opposite axial poles similar to those found associated with the earth.

This periodic turbulent condition of the sun spots not only makes evident changes in the magnetic properties of the earth amounting at times to magnetic storms, but it would appear that this turbulence as well as the turbulence of the chromosphere appears to have a marked disturbing effect on the electrical conditions on the surface of the earth made evident by pronounced changes in the intensity of short-wave radio reception or possibly in some of the "statics" accompanying the reception. That there is a definite connection between the magnetic disturbances, sun spot activity and change of intensity of radio reception or "radio fade-outs" seems to be definitely established by the work of J. H. Dellinger, Chief of the Radio Section of the Bureau of Standards and by Professor Henry G. Gale and Mr. R. S. Richardson at Mount Wilson as well as by several other observers. Further, there seems to be a connection between some of the disturbances in the chromosphere and in the sun spots for Dr. Philip C. Keenan of the staff of Yerkes Observatory has discovered streamers extending outward from the sun 500,000 miles which may be designated as sign posts to the sun spots. However, the relationship of these disturbances to the radio fade-out is not at all simple and theories of the mechanism by which the connection is established are necessarily highly speculative.

V. Investigations in the Atmospheric Conditions of the Planets.

The existence of forms of life on other planets not differing greatly from that which we have on the earth is a problem for investigation to which much attention can justifiably be given. This would apparently require conditions of temperature and constituents of enveloping atmosphere somewhat similar to conditions associated with the earth. Speculations as to the existence of forms of life differing widely from that which we experience are unavailing and perhaps even vexatious. The widespread intense interest in the problem has given rise to extensive investigations. Perhaps also the fact that the information obtained is of conditions that are currently

existent in contrast to the information obtainable in stellar investigation inspires a greater satisfaction in the interpretation. The results of recent investigations on the planets may be summarized and speculations as to the existence of life based on this information together with information previously obtained may be left to the individual.

The smaller planets Mercury, Venus and Mars. From their densities they, like the earth, must be masses of rock with cores of metallic iron or other heavy metals.

1. Mercury.

(a) From the appearance of markings—sometimes shrouded—Dr. Antoniadi of the Paris Observatory says it has a very highly rarefied gaseous envelope in which clouds are floating at high elevation.

(b) Theoretical physicists doubt the above because of the small mass of the planet, at any rate for the lighter gases, which, due to their expanding velocity, should escape from the planet.

(c) The transit of Mercury across the sun on May 11, 1937, visible in southeastern Europe and Africa, will afford a possible opportunity to obtain evidence. When the planet is half in front of and half off the solar disc the presence of an atmosphere should make itself evident by a ring of light which, due to refraction by the atmosphere, appears completely around the planet.

(d) Vegetation and life such as we know it on the earth probably do not exist.

2. Venus.

(a) There is spectroscopic evidence of an atmosphere surrounding Venus in which there is an abundance of carbon dioxide as well as the ring phase when Venus is near the sun which indicates atmospheric refraction. This was probably the condition once existing on the earth and here a vegetation developed which absorbed the carbon and freed the oxygen. The mass of Venus is not great enough to retain hydrogen gas and therefore water does not form. Moreover, being near the sun, its temperature is high and it has probably failed to develop life as we know it on the earth.

(b) The existence of clouds in the atmosphere is apparent. Continuous observations of the markings on Venus indicate a changing

condition in the definition and form of the markings which would suggest a shrouding action by clouds.

3. Mars.

This is the planet that has given rise to intensive investigations in recent years. Its mass, temperature, period of revolution about the sun seem to be like the earth as suitable for the existence of an atmosphere and vegetation that would be conducive to the support of life as we know it. It has been the subject of much direct observation as well as spectroscopic investigation by many observers. A very enthusiastic industrious committee of the British Astronomical Association has collected the results of extensive observations.

There are markings on the planet's surface that are very distinct that seem to indicate

(a) dried out sea beds with bordering promontories;

(b) canals natural or artifical with at times barren borders and at other times an appearance that would suggest vegetation on the banks;

(c) one and perhaps two polar snow caps which wax and wane seasonally;

(d) an atmosphere containing water vapor and possibly CO_2, H and N, but extremely small amount of oxygen. The presence of water vapour is perhaps problematical but as the temperature is generally low, water is in general in the form of liquid or solid and the absolute humidity is low;

(e) that there is evidence of the existence of clouds or bluish haze in the atmosphere of Mars.

The conditions on Mars approximate the conditions on the earth, but probably not closely enough to warrant the conclusion that the existence of life such as we know it is possible, though these conditions may permit of the existence of life in a form not greatly different from some of the forms of life on the earth.

The major planets, Jupiter, Saturn, Uranus, and Neptune.

(a) Jupiter and Saturn possibly have cores of rock or metal like the minor planets.

(b) All have atmospheres possibly of hydrogen or helium containing clouds of condensed light materials like ammonia, methane and ethane in liquid or solid form which extend to great depth.

VI. Investigations on Cosmic Rays.

The discovery of radioactive Uranium salts was made by Becquerel in 1896 and the isolation of polonium and radium was accomplished by the Curies in 1900. Radium salts were found to emit a gas called the radium emanation and three radiations, the α radiation, positively charged particles, the β radiation, negatively charged particles, and the γ radiation, a wave radiation like ultra-violet light waves or more closely resembling X rays of very short wavelength of the order of one ten-thousandth of a millimeter and which was more penetrating than the α or β radiations; in fact, the α and β radiations could be screened or absorbed by a very thin sheet of paper or light metal while the γ radiation requires a much greater thickness of a heavy metal like lead to produce measurable screening. The radiations had an ionizing effect on gas conductors and could thus be readily investigated by the rate of leak or discharge of electricity from a charged electroscope. Immediately there commenced an intensive search by means of the electroscope for other radioactive substances and for more definite knowledge of the properties of the radiations. Among the investigators were the late Professor McLennan and Professor Burton and research students in Physics at the University of Toronto and Professor Rutherford and members of the staff in Physics at McGill University. It was found difficult to keep the charge from leaking away from their electroscopes even when screened with lead sheets of considerable thickness. This was rather naturally ascribed to deep-seated radioactive materials in the earth which emitted a very penetrating γ radiation which was shown by Moseley in 1912 to be very short X rays. Electroscopes were lowered to some depths in lakes in order to determine the screening effect and it was found that the most penetrating rays required a screen thickness of 1½ meters of water or 6 inches of lead to reduce their intensity to 1/200 of their initial intensity. These rays were known to have an energy of 2.6 million electron volts. No one prior to 1910 had obtained information on more penetrating radiations. In 1910 Gockel, a Swiss scientist, using an electroscope in a balloon, found that the further from the earth the faster the leak of his electroscope, and he proved definitely that there were other radiations coming in from beyond the earth, for the leak of the electroscope

should become less the farther away he was from the earth if the discharging effects were due to γ rays from radioactive materials in the earth. Hess in Austria confirmed Gockel's results in 1911, and suggested two possible sources of the new radiation, (a) radioactive materials in the upper atmosphere, (b) a source of radiation beyond the atmosphere which of necessity emitted a more penetrating radiation than γ rays.

The results were still further confirmed by Kohlhörster in 1910-1912. Measurements were made by Kohlhörster on the leakage of the electroscope up to a height of 9 kilometers, at which height the leak was seven times that at the surface of the earth and Regener detected their presence at a depth of 700 feet in a mountain lake. In 1922 Millikan confirmed the increase in rate of leak with height up to 15.5 kilometers. From 1922 to 1925 by using lead shielding for their electroscopes several experimenters showed definitely that there were rays at least 50 times as penetrating as the γ rays from radioactive materials in the earth. Extensive efforts were then made to determine the origin of these rays, now designated cosmic rays. Electroscopes with automatic recording devices were sent to greater heights in the atmosphere and measurements on intensity and penetrability became routine by parties on balloon flights into the stratosphere. The upper atmosphere as a source was excluded. Only slight evidence was found of any direct influence of the sun or of the Milky Way as the earth rotated during the course of a series of measurements. The evidence seemed to point to an extra-galactic origin. In this connection attention is called to the fact that if the source of the cosmic rays is extra-galactic, then there should be a Doppler effect on the intensity and number of cosmic rays received per second, and there should be therefore a variation in the intensity of the cosmic rays with sidereal time at any point on the earth as the point moved with the rotation of the earth from the front facing the approach of the ray to the back and modified therefore by the depth of the earth's atmosphere through which the ray passes. The magnitude of the resultant variation was calculated in 1935 by A. H. Compton and Ivan A. Getting on the supposition that the origin of the cosmic rays is extra-galactic and that our galaxy is a centre of symmetry with respect to the source, and a comparison with the average

values of the variation measured by Hess and Steinmaurer shows approximate agreement with the calculated values. Recent investigations by Richard L. Doan shows a rough correlation with barometric pressure. A very extended series of observations would be required to determine if there is a change in the Doppler effect during a single galactic rotation as a check on the assumed symmetrical distribution of the rays.

Previous to 1931 only the ionized effect of the cosmic rays on air as shown by the leak of a charged electroscope was used to investigate the rays and their energy was inferred from their penetrability and from this also their source was considered to be as distant at least as the sun. It was known, however, that ionizing effects of other rays could be made evident by the condensation of vapour on the electrons in a saturated gas. This was successfully accomplished for cosmic rays in 1931 by Dr. Anderson who was working with Professor Millikan at Pasadena using a saturated gas in a chamber surrounded by lead. The information obtained was startling.

(a) The nuclei of atoms were apparently disrupted by the cosmic rays, still considered to be of a wave or photon character, and high speed negative electrons (or negatrons) and positive electrons (or positrons) were ejected and because of their ionizing effect on the gas produced condensation trails in the gas.

(b) To disrupt the atoms and free the positrons the energy of the cosmic rays was necessarily tremendously high, and was calculated from the deflection of the electron and positron trails by a magnetic field to reach as high as 10 thousand million electron volts. Energies of such magnitude contributed support to the notion that the origin of the rays was indeed cosmic and a rapid succession of theories of their stellar origin appeared, their wave or photon character being still largely taken for granted. Moreover their distant origin, together with their supposed wave character, supported the notions that they must reach the earth vertically and that their vertical intensities should be uniform at all points on the earth at the same level (say sea level).

Extensive measurements by many experimenters at numerous widely scattered points on the surface of the earth and at great heights in the atmosphere showed that marked variations with

latitude and longitude exist, the minimum intensity being in the neighbourhood of the equator, but the variations with latitude and longitude did not obey a simple law. Cosmic ray intensity contours did, however, have a rough correspondence to geomagnetic contours, especially to the isogonic or horizontal component intensity lines. Immediately the interpretation became insistent that the cosmic rays were in part at least not waves or photons but were charged corpuscles like negatrons, positrons, protons or α particles and were deflected in their path by the magnetic field of the earth. A new method of investigation was called into action to investigate this corpuscular radiation, the Geiger counter. This was a cylinder of gas which could be ionized, but instead of making use of the usual method of measuring the electric current of the ions they were carried to the grid of a triode detector and with the assistance of a radio amplifying speaker the existence of the cosmic rays was made evident audibly. Ingenious arrangements of multiple Geiger counters set up by the staff of the Bartol Foundation of the Franklin Institute were used by them and by others at various points to measure the intensity and angular distribution about the vertical plane of the cosmic rays. The interpretation of the results of these investigations seems to favor the conclusion that the rays at the earth's surface are charged corpuscles and very largely positrons, though other suggestions that they are of a complex character comprising photonic and corpuscular elements in primary and secondary and even tertiary radiations are presented.

The magnitude of the deflection of the cosmic rays by the earth's magnetic field is small but it is sufficiently large to require a distant origin for the rays even if the corpuscular character existed at the source in order that the passage through the magnetic field of the earth will be sufficiently long to provide for the measured deflection.

Theories of their origin are at present highly speculative, suggestions being presented that they are emitted with the rapid atomic changes in outbursts of novae or in rarefied high temperature nebulae or that they are positrons drawn from distant stars by clouds of negatively charged dust in the atmosphere of the stars, the clouds acting like grids through which the high speed positrons pass. There is also the suggestion that the earth is highly charged negatively due

to negatrons or negative electrons from the sun and that the positrons which appear to be the main constituent of the cosmic rays are thus highly accelerated towards the earth. Their passage through even the thin matter which is known to exist in space or through the atmosphere of the earth may produce secondary radiations, corpuscular or photonic in character. It is of interest to note that Professor Joseph Kaplan of the University of California at Los Angeles suggests this as the source of the prevalent light in the night sky, a condition that at times prevents the astronomers from making use of long exposures with their photographic plates.

Up to the present stellar investigation has been entirely dependent on our three classes of radiatron, infra-red, visible, and ultra-violet light rays. The location of the source of cosmic rays among the stars will inevitably herald the dawn of a new era of astronomical research. However, it must be noted that while single cosmic rays possess more energy than any other known form of energy and they are detectable one at a time, for about 25 cosmic ray shots pass through one's body per second, yet the total energy of cosmic rays falling on the earth is about one one-thousandth of star light or one one-millionth of sun light.

MINUTES OF THE ANNUAL MEETING OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The annual meeting of the Royal Astronomical Society of Canada was held in the Physics Building of the University of Toronto on January 14, at 8 p.m. Lachlan Gilchrist, M.A., Ph.D., presiding.

The minutes of the last annual meeting were taken as read. Reference at the outset was made to the passing of Mr. R. A. Gray, the General Secretary and Librarian, on December 24 last. Then followed the reading of reports for the year 1935. The Assistant Secretary read the reports of the Librarian and Secretary; these were accepted on motion by Miss Budd, seconded by Mr. Horning. Mr. Horning presented his report as Treasurer, which was regularly adopted.

The Curator, Mr. Duncan, also presented his report.

The president announced that the secretaries of the various centres had sent in their reports, and the meeting wished these reports to be taken as read; they will appear in detail in the March issue of the JOURNAL as usual.

The auditors, Mr. A. R. Hassard, and Mr. J. E. Maybee, were on motion thanked for their work in auditing the books of the Society for 1935 and were duly appointed for another year.

A suggestion was passed on to Council, that the telescopes be carefully examined for repairs, and the slides be gone over with a view to augmenting them with newer, up-to-date subjects. Also the Curator should receive assistance, if needed, in the work. That more use be made of this property in public meetings, was urged by the members.

Scrutineers were appointed to count the ballots and the result of the count was announced by Mr. F. Troyer. The nominations as presented by the Council were approved by an almost unanimous vote. However on account of the death of Mr. R. A. Gray, who had been re-nominated for the positions of General Secretary and Librarian, those offices were vacant. The President then declared the Officers and other members of the General Council for 1936 to be the following:

Honorary President—The Hon. Leonard J. Simpson, M.A., Minister of Education for the Province of Ontario.

President—R. E. DeLury, M.A., Ph.D., Ottawa.

First Vice-President—Wm. Findlay, M.A., Ph.D., Hamilton, Ont.

Second Vice-President—J. A. Pearce, M.A., Ph.D., Victoria, B.C.

General Secretary—

General Treasurer—J. H. Horning, M.A., Toronto.

Recorder—E. J. A. Kennedy, Toronto.

Librarian—

Curator—R. S. Duncan, Toronto.

Council—D. S. Ainslie, M.A., Ph.D., Toronto; F. Napier Denison, Victoria; Miss A. Vibert Douglas, Ph.D., Montreal; E. A. Hodgson, M.A., Ph.D., Ottawa; Dr. G. R. Magee, London, Ont.; J. E. Maybee, Toronto; P. M. Millman, Ph.D.; A. Thomson, M.A., Toronto; John Satterly, M.A., D.Sc., Toronto; L. A. H. Warren, M.A., Ph.D., Winnipeg; and the presiding officer of each Centre.

A vote of thanks of the Society to the Officers for their work during 1935 was moved by Mr. F. Troyer, and approved by all present. The meeting then adjourned.

E. J. A. KENNEDY, *Recorder.*

CURATOR'S REPORT

The telescopes have been in use most of the time. The lantern slides, while not in use as much as in former years, have nevertheless been put to good use by some of the members in giving elementary talks in churches, etc. Some of the much used slides have suffered somewhat from damage and breakage and ought to be replaced with more up to date ones.

ROBT. S. DUNCAN, *Curator.*

LIBRARIAN'S REPORT

The various issues of the technical periodicals sent to the Society in exchange for the JOURNAL, after remaining on the library tables for about a month, have been sent to the David Dunlap Observatory. These publications are still available for loan to members when asked for.

29 Volumes have been bound during the year at a cost of $63.56.

115 Books were borrowed by members during the year. Members have not all kept to the ruling made by the Librarian in the report of last year—that books should be returned or renewed at the end of a month. They are requested to do so.

Additions to the library during the year include periodicals from:

Canada and the Empire	168
The United States	173
Other Countries	180
Total	502

The JOURNAL was sent to the regular list of exchanges.

EVA M. BUDD,
Assistant Librarian

REPORT OF THE ASSISTANT GENERAL SECRETARY

MEMBERSHIP OF THE SOCIETY

The Membership of the Society on December 31, 1935, as shown by the reports of the various Centres, was as follows:

	1934	1935
Toronto	174	177
Ottawa	62	65
Victoria	119	122
Montreal	107	123
Winnipeg	73	38
London	52	48
Hamilton	54	58
Vancouver	73	48
Edmonton	54	48
Members at Large	133	143
Calgary	...	12
Total	901	888
Subscribers to JOURNAL	65	59

Among the deaths of members during the year should be noted the names of F. L. Blake, D.L.S., formerly of the Meteorological Service, Toronto; W. L. Haight, K.C., Parry Sound; Dr. Edwin

Brant Frost, Honorary Fellow of the Society; Rev. W. M. Kenny, Wyebridge, Ont., formerly of Toronto; C. L. Strachan, Kindersley, Sask.; Rev. J. T. W. Claridge, Melton Mowbray, England; R. A. Gray, B.A., Librarian and General Secretary of the Society at the time of his death.

The new Centre at Calgary has not materialized so well as expected, but will probably grow steadily.

Attention might be directed to the successful summer course of the Victoria Centre, the good average attendance at the London Centre meetings, the home-made telescope of C. G. Wates of the Edmonton Centre, and the very successful field-night in June of the Hamilton Centre.

The illness, and later the death, of Mr. Gray, the General Secretary, delayed the sending out of the new Membership Cards, which are now available for all Members.

EVA M. BUDD,
Assistant Secretary

REPORTS FROM THE SECRETARIES OF THE CENTRES

TORONTO CENTRE

Membership as on December 31, 1935:	
Resident in Toronto	127
Life Members	7
Non-resident Members	43
Total	177

There were 174 members at the beginning of the year 1935, 26 have been elected during the year and 23 members resigned, so that the position is slightly better than last year. The reasons for these resignations should be investigated and remedies applied wherever possible. An annual drain of twenty per cent. in membership cannot be charged entirely to the depression, the membership fee being so small. The interest of the members, old and new, must be sustained.

The subjects and speakers during 1935 were as follows:

Jan. 29—H. G. Duncalfe: Some Popular Fallacies regarding Natural Phenomena—the Moon, the Rainbow, etc.

Feb. 12—Miss E. J. Allin, M.A., Ph.D.: Exploding Atoms—Recent Investigations of the Structure of the Nucleus.
Feb. 26—Prof. R. K. Young: Planetary Atmospheres.
Mar. 12—Prof. A. F. C. Stevenson, M.A., Ph.D.: Simon Newcomb Centenary. His Contributions to Astronomy and Mathematics.
Mar. 26—Prof. A. P. Coleman: The Recurring Ice Ages; Some Personal Experiences in Recent Explorations.
Apr. 2—Special meeting jointly with the University of Toronto, Department of Astronomy, to view the six reel motion picture film, "Looking Through Great Telescopes."
Apr. 9—S. C. Brown: Telescope Making for Amateurs.
Apr. 30—Dr. Helen S. Hogg: Mars.
May 14—Rev. C. H. Shortt, M.A.: Great Astronomers.
June 22—A special meeting held at the David Dunlap Observatory, to view the new large Telescope.
Oct. 8—Reports of Summer Observations, by several members.
Oct. 22—Andrew Thomson, M.A.: Terrestrial Atmospheric Tides.
Nov. 5—J. R. Gilley, B.A.Sc.: This Question of Calendar Reform.
Nov. 19—F. S. Hogg, M.A., Ph.D.: New Stars.
Dec. 3—Dr. C. A. Chant: Meeting of the International Astronomical Union at Paris in July, 1935.
Dec. 17—Winter Observations, by the Members; also moving pictures.

S. C. Brown, *Secretary*

Calgary Centre

During the past year, a number of Calgarians interested in astronomy formed a group, which was later recognized by the Council of the Society as the Calgary Centre.

Several meetings have been held, at which talks on astronomy were given. Slides were also obtained from the University of Alberta in Edmonton, and an interesting lecture was delivered.

These meetings were all attended by numbers of interested persons, many of whom expressed a desire to belong to the Society. Unfortunately, however, the financial response is not in proportion to this. To date, only 9 are paid-up members, although several more are members of other Centres, not yet having transferred.

Considerable observing is carried on by means of several fine instruments belonging to members of the Centre, notably two 10-inch reflectors made by the president, Mr. H. C. King.

May we here express our sincere thanks for the help rendered us by the General Secretary, and others of the Society.

G. F. Moore, *Secretary*

Edmonton Centre

The Centre held seven regular meetings in 1935, apart from the annual dinner meeting and two meetings of Council. In accordance with a policy decided on early in the year, most of the papers presented dealt with some aspect of the earth, considered as an astronomical body. At each meeting a short talk was also given on prominent objects in the night sky for the month and on other points of current astronomical interest.

Following is the list of speakers and their subjects:

Jan. 10—C. G. Wates: The Construction of a Home-made Telescope.
Feb. 14—Dr. J. W. Campbell: The Motions of the Earth.
Mar. 14—Prof. E. S. Keeping: Weighing the Earth.
Apr. 11—W. O. Coulman: The Tides.
May 16—Dr. C. S. Beals: What is a Star?
Oct. 10—Dr. R. L. Rutherford: The Structure of the Earth.
Nov. 14—Prof. L. H. Nichols: The Earth's Atmosphere.
Dec. 12—(Annual Meeting), W. H. Poole: Galileo.

During the year the following new members were elected: Miss M. Hamilton, Prof. H. W. Hewetson, Messrs. F. W. Coppey, C. G. Wates, P. H. Knepp, F. J. Speed, and J. H. Ogilvie.

The following deaths occurred during the year: Messrs. W. H. Tucker, W. E. Rose.

The membership is now 48. Membership cards have been printed and issued to paid-up members.

E. S. Keeping, *Secretary*

Hamilton Centre

During 1935 nine regular meetings and several council meetings have been held.

The regular meetings were as follows:

Jan. 8—W. S. Mallory: The Harmony of the Universe.
Feb. 12—A social "get acquainted" evening, during which several members gave short talks.
Mar. 12—Prof. Wiles: Astronomy in English Literature.
Apr. 9—Dr. Findlay: Remarkable Measurements.
May 21—Dr. W. E. Harper, of Victoria, B.C.: Western Observatories and their Work.
June 11—Annual Field Night.
Oct. 8—J. A. Marsh: Her Lunar Majesty—the Moon.

Nov. 14—Prof. A. E. Johns: The Runaway Universe.
Dec. 12—Annual meeting. Several members gave short talks on "The Interest of Astronomy for the Amateur."

The programmes of the past year have been particularly interesting and it is gratifying to note that all except two have been presented by members of the Hamilton Centre. The Field Night, held in June was outstanding, and the growing interest in astronomy was shown by the record attendance of approximately 450 visitors.

The membership at the beginning of the year was 54; 7 have withdrawn and 11 new members have been added, making a total at the end of the year of 58.

The enthusiasm of the members and the sustained interest of many non-members have resulted in a year of much progress and we look forward to a continuance of the good work during 1936.

NORMAN GREEN, *Secretary*

LONDON CENTRE

During 1935 the London Centre held nine regular meetings, with a total attendance of 409. A summary of these meetings follows:

Jan. 11—Dr. H. R. Kingston: The Way of the Moon. Attendance 55.
Feb. 8—Dr. F. S. Hogg (Toronto): Investigations on Variable Stars. Attendance 43.
Mar. 8—Dr. L. Gilchrist (Toronto): Physics in the Service of Astronomy. Attendance 125.
Apr. 12—J. Middlebrook: Methods of Observing Meteoric Showers. Attendance 31.
May 10—Debate: Resolved that the Thirteen Month Calendar is preferable to the Modified Twelve-Month Calendar. Affirmative—J. Higgins, Mrs. Davies. Negative—Dr. H. S. Wismer, Miss Livingstone. Attendance 42.
June 22—Annual Picnic at the summer home of Dr. Ainslie, St. Mary's. Attendance 25.
Oct. 12—J. Middlebrook: A report of observations made on the Perseid meteors. F. Coates: A Visit to Optical Works in England, Belgium and Holland. Rev. W. G. Colgrove: A Demonstration of a Model Planetarium. Attendance 25.
Nov. 8—Dr. G. R. Magee: An Historical Account of Comets. Attendance 23.
Dec. 13—Annual Meeting—Moving Pictures. Attendance 40.

Current Topic discussions, Constellation Studies, and Observer's Hand Book discussions were features of the monthly

meetings. Members taking part in these activities were T. C. Benson, Dr. H. R. Kingston, E. H. McKone, George Gunn, Fred Coates.

Two Executive Committee meetings were held during the year—the first on Dec. 27, 1934, to arrange the programme for 1935; the second on April 12, 1935. At this latter meeting, the Committee appointed the late Mr. A. J. Doke to interview Premier Hepburn regarding the continuance of the Provincial grant to the Royal Astronomical Society of Canada. This interview was obtained, and Mr. Doke later received a letter from the Minister of Education stating that the grant would be continued.

The Meteor Observation Group of the London Centre observed and plotted the Perseid Meteoric Shower of last August. The results of these observations have been sent to Toronto. This group is directed by Mr. J. Middlebrook. Inclement weather prevented any observations of the Leonid Shower in November.

The March meeting of the London Centre was preceded by a dinner at Hotel London in honour of Dr. Gilchrist, the guest speaker of that meeting. There were 33 members present at this dinner.

The London Centre wishes to record its loss in the passing of Mr. A. J. Doke. Mr. Doke was a valued member of the Council for 1935, and at all times was active in serving the best interests of the London Centre.

The total membership for the year 1935 was 43.

G. R. MAGEE, *Secretary*

MONTREAL CENTRE

During the 1934-35 season there were seven meetings of the Society, as follows:

Nov. 2—Mr. Erland Echlin (Toronto): Calendar Reform.
Dec. 4—Dr. A. V. Douglas (McGill): The Outer World.
Jan. 18—Dr. C. A. Chant (Toronto): David Dunlap Observatory.
Feb. 28—Prof. A. H. S. Gillson (McGill): Conic Sections and Astronomy.
Mar. 26—Dr. S. A. Mitchell (Leander-McCormick): A South Seas Eclipse Expedition.
Apr. 25—Mr. E. Russell Paterson (Montreal): Meteors. Mr. F. DeKinder (Montreal): Summer Observations. Mr. G. Harper Hall (Montreal): Photography in Relation to Astronomy.
May 2—Motion Pictures, Through Great Telescopes (Araneff Co., Chicago).

There were six meetings of the Council. The nucleus of a library was formed in April and Mr. F. DeKinder named as Hon. Librarian. Observational meetings were held weekly throughout the summer on the roof of the Sun Life Assurance Building, by kind permission of the authorities, and during the early autumn on the roof of the Engineering Building of McGill University, through the courtesy of the University authorities concerned.

The membership list contains 123 names at this date, 10 new members being elected during the year and 10 names withdrawn for various reasons.

A. V. DOUGLAS, *Secretary*

OTTAWA CENTRE

During 1935 there were four Council meetings, and six public lectures were given in the Victoria Memorial Museum:

Mar. 8—Director R. M. Stewart (Dom. Obs.): Cosmogony and Cosmology.
Mar. 15—Professor A. H. S. Gillson (McGill Univ.): The Stellar Universe.
Mar. 22—Dr. R. J. McDiarmid (Dom. Obs.): The Solar System.
Mar. 29—Dr. R. E. DeLury (Dom. Obs.): The Sun.
Apr. 5—Dr. P. M. Millman (Univ. of Tor.): The How and the Why of Meteor Observing.
Dec. 18—Dr. E. A. Hodgson (Dom. Obs.): The Earthquake of Nov. 1, 1935.

In addition there was a meeting for members only at the Museum for the purpose of viewing the motion picture, "Looking through Great Telescopes". This picture was loaned to the Society by R. B. Shaw of the Dominion Educational Pictures.

Outdoor Meetings: The one outdoor meeting called for Friday, April 12, at the Observatory grounds was necessarily cancelled due to unfavourable weather.

Meteor Observing: Meteor observations were carried out during the Perseids, August 1 to 15, and during the Leonids, November 15 to 17. For the Perseids 23 people participated, the majority being high school students. Some observations were made from a field north of Ottawa, most of them being made from the roof of the Observatory. The Leonids were observed from the roof of the Health of Animals Research Station, Hull, through the courtesy of Dr. E. A. Watson, Director. The results were all forwarded to Dr. P. M. Millman of Toronto.

Membership: At the end of 1934 our membership was 62. During the year five were taken from our list, one for lapse of fees, one being transferred, and three having resigned in good standing. Against this is recorded a gain of eight members, one a transfer, which makes a net gain for the year of three. Our membership at the close of 1935 is 65.

Publications: This centre has no publication of its own though such has been advocated and discussed from time to time in executive meetings. Contributions from our members have been made to the JOURNAL of the R.A.S.C. Through the courtesy of the Director, Mr. R. M. Stewart, Observatory star maps have been sent out to new members, while the Saturday evening programme bulletin of the Observatory has been sent regularly to all members as in the past.

MALCOLM M. THOMSON, *Secretary*

VANCOUVER CENTRE

Vancouver Centre has passed through a very satisfactory year, all meetings being well attended, including our three summer meetings at the homes of members.

We have 48 members but only 37 paid up subscriptions. It is hoped to be able to reinstate those behind in their dues. Seven new members were elected during the year and one resigned. Eight regular meetings were held at the University of British Columbia.

The meetings were as follows:

Jan. 8—Dr. G. M. Shrum (Univ. of B.C.): The Old and the New Radioactive Substances.
Feb. 12—Dr. F. S. Nowlan (Univ. of B.C.): The Romance of Numbers.
Mar. 12—Dr. C. S. Beals (Dom. Ast. Obs.): What is a Star?
Apr. 8—H. P. Newton, Esq.: Astronomical Work for Amateurs.
May 14—Members' Night and Annual Dinner.
—Summer session: Three meetings at the homes of members.
Oct. 8—Dr. R. M. Petrie (Dom. Ast. Obs.): Analysis of Starlight.
Nov. 12—Dean D. Buchanan (Univ. of B.C.): Myths of the Constellations.
Dec. 10—Annual Meeting, Election of Officers, Demonstration Night.

At the May meeting, four members, Mrs. Laura Anderson, and Messrs. J. W. Moore, Seto More and Paul Sykes, addressed the

Centre respectively on: The Moon, The Sun, The Planets and Asteroids, and The Stars of the Month. Each gave a very interesting address.

We are pleased to welcome to our Centre a past-president and valued member from Winnipeg, Mr. C. E. Bastin, who conveyed greetings from Winnipeg and was heartily welcomed by our president, Prof. W. H. Gage.

The Secretary wishes to thank all officers, the council and members for their valuable help during the past year; also the General Secretary and staff for their assistance.

C. A. McDONALD, *Secretary*

VICTORIA CENTRE

Membership:		
Total membership as at Dec. 14, 1934		119
New members secured during 1935		21
		140
Less:		
Members deceased	3	
" resigned	5	
" transferred	5	
" dropped for non-payment of dues	5	
	—	18
Total membership Dec. 1, 1935		122
Membership made up as follows:		
Life members	2	
Honorary members	1	
Junior members	14	
Out of town members	29	
Local members	76	
Total	122	

Meetings: During the year there were held nine regular meetings and four meetings of the Council, these, together with eight "Summer evenings with the Stars" make a total of 21 meetings held during the year.

General: The Society has had a fairly successful year financially. We are gradually liquidating our obligations to Toronto, having

paid in full our 1934 dues and also $50.00 on the current year. The Summer Course aided our finances to the extent of $17.00 net above expenses. Dues outstanding at the above date amounted to $34.00. The attendance at all meetings has been very good, the high quality of the lectures given no doubt being largely responsible.

The Summer Course proved to be a decided success in interest and publicity, besides being a financial asset. Less than $3.00 was spent on advertising, yet there appeared twenty different items in the local papers, twelve of these being in two column form. In addition, two radio broadcasts were given over CFCT, no charge being made for the facilities. The average attendance at the Summer Course was 68. The Telescope Making section under the direction of Mr. Hobday is proving of considerable interest and one foresees the gradual development of many amateur telescope makers through this section.

May I tender this report with my sincere hope that the coming year will prove the best yet in promoting amongst our fellow citizens the study of Astronomy, the most inspiring of all the sciences.

GORDON SHAW, *Secretary-Treasurer*

FINANCIAL STATEMENTS, 1935

I. GENERAL TREASURER

GENERAL ACCOUNT

Receipts		Disbursements		
Balance from 1934	$1,043.65	Publications		$1,732.50
Grants	2,270.00	Public Meetings		79.90
Fees	1,532.95	Library		12.23
Publications	206.63	Stamps and Stationery		260.10
Interest	168.87	Salary, Asst. Secretary		660.00
Stamps and Stationery	21.00	Janitor		12.00
		Rent		120.00
		Grants:		
		Calgary	$8.95	
		Edmonton	42.50	
		Hamilton	24.00	
		London	53.50	
		Montreal	99.00	
		Toronto	153.50	
		Vancouver	42.25	
		Victoria	103.50	
		Winnipeg	8.75	
				$535.95
		Miscellaneous		35.75
		Bank Balances		1,794.67
	$5,243.10			$5,243.10

LIFE MEMBERSHIP ACCOUNT

Receipts		Disbursements	
Balance, 1935	$270.69	Interest to General Account	$74.30
Life Member	25.00	Bank Balance	240.73
Bank Interest	3.84		
Bond Interest	15.50		
	$315.03		$315.03

BUILDING FUND ACCOUNT

Receipts		Disbursements	
Balance, 1934	$729.52	Safe-keeping Bonds	$2.00
Bank Interest	11.18	Balance	919.96
Bond Interest	181.26		
	$921.96		$921.96

SOUTHAM PRESS FUND ACCOUNT

Held in General Bank Account

Receipts		Disbursements	
Balance, 1934	$268.11	Nil.	
Bank Interest, 2%	5.36	Balance	$338.47
Bond Interest	65.00		
	$338.47		$338.47

(Signed) J. H. HORNING, *General Treasurer*

Audited and found correct, January 8, 1936

J. Edw. Maybe—

A. R. Hassard —*Auditors*

MEMO—BONDS HELD BY THE IMPERIAL BANK FOR SAFE-KEEPING

Bond belonging to	Description of Bonds	Face Values	Date of Maturity	Rate of Int.	½ yr. Coupons	Dates of Int.	Total Int.
Life Members Acc.	D of C R_2TA083071	100	1943	5%	$2.50	Apr. 15	$5.00
	R_2TA083072	100	1943	5%	2.50	Oct. 15	5.00
	Can. Perm. Mge. 420933	100	1937	5½%	2.75	June 1	5.50
						Dec. 1	
							15.50
Building Fund	D of C C_4E014437	1000	1949	3½%	18.75	Oct. 15	
						Apr. 15	37.50
	D of C N_2E029210	1000	1941	5%	25.00	May 15	
						Nov. 15	50.00
	Can. Perm. Mge. Cpn.						
	L15591	500	1940	3¾%	9.37½	June 1	18.75
	L15592	500	1940	3¾%	9.37½	Dec. 1	
	L13275	500	1936	5%	12.50	June 1	25.00
	L20932	500	1937	5½%	13.75	Dec. 1	27.50
							177.50
Southam Press Fund	D of C N_1A013817	100	1936	5%	2.50	May 15	
						Nov. 15	5.00
	D of C N_1A013818	100	1936	5%	2.50	"	5.00
	D of C N_1A013819	100	1936	5%	2.50	"	5.00
	D of C N_2E008218	1000	1941	5%	25.00	"	50.00
							65.00

II. TREASURERS' REPORTS OF CENTRES

1. TORONTO CENTRE

Receipts		Disbursements	
Balance, Jan. 1, 1935	$220.57	Rent	$60.00
Grant from General Council	153.50	Printing Notices	21.85
		Advertising	14.80
		Stamps, Treasurer	.96
		Programmes	41.78
		Stamps & P.C. Gen. Treas.	21.00
			$160.39
		Balance to 1936	213.68
	$374.07		$374.07

2. MONTREAL CENTRE

Receipts		Disbursements	
Balance, Oct. 15, 1934	$268.97	Remitted to Gen. Treas.	$230.00
Members Fees (115 at $2)	230.00	Typing, etc	5.18
Grant from Gen. Treas.	99.00	Expenses *re* Meetings	56.46
Donations	17.94	Postage	14.37
Bank Interest	8.94	Stationery	7.91
		Secretarial Assistance	12.00
		Library	13.09
		McGill University	7.00
		Sundry Expenses	4.73
		Telescope expenses	5.15
		Balance, Oct. 15, 1935	268.96
	$624.85		$624.85

3. OTTAWA CENTRE

Receipts		Disbursements	
Bank Balance, Jan. 1, 1935	$165.21	Amt. sent to Head Office	$71.00
Amount Collected in Dues	112.00	Printing and Stationery	11.33
Interest on Deposits	1.11	Postage	6.00
		Advertising	27.60
		Expenses of Lectures	59.44
		Bank Balance, Dec. 31, 1935	102.65
	$278.32		$278.32

4. HAMILTON CENTRE

Receipts		Disbursements	
Bank Balance	$ 7.63	Printing	$ 18.35
Membership Fees	58.00	Stamps and Exchange	1.42
Donations and Loan	19.00	Loan	20.58
Toronto Cheque	24.00	Lecture Room	10.00
Interest	.16	Cheque to Toronto	58.00
		Bank Balance	.44
	$108.79		$108.79

5. LONDON CENTRE

Receipts		Disbursements	
1934 Bank Balance	$121.88	Secretarial Expenses	$ 53.73
48 Members' Dues	96.00	Remittance to Gen. Treas.	96.00
Grant	53.50	Dinner	48.65
Dinner Receipts	32.00	Lecture	10.10
Donations	3.75	Rubber Stamp	1.30
Bank Interest	2.17	Stamps and Exchange	1.08
		Advertising	9.70
		Telephone, etc	4.57
		Flowers	3.50
		Balance	80.67
	$309.30		$309.30

6. WINNIPEG CENTRE

Receipts		Disbursements	
Balance from 1934	$ 7.75	Advertising	$ 8.05
Grant from Gen. Treas.	8.75	Printing	9.27
Fees for 1932	2.00	Exchange	.38
1933	2.00	Honorarium	7.50
1934	16.00	Rent	6.00
1935	62.00	Flowers	2.00
1936	10.00	Stamps	10.13
Bank Interest	.26	Fees to Gen. Treas.	70.00
Balance owing Treasurer	5.00	Balance, Dec. 11, 1935	.43
	$113.76		$113.76

7. EDMONTON CENTRE

Receipts		Disbursements	
Bank Balance, 1934	$ 35.73	Stamps	$ 5.03
Fees, 49 at $2.00	98.00	Song Sheets	.30
Grant from Toronto	42.50	Receipt Book	.25
Bank Interest	2.17	Rubber Stamp	3.02
		Janitor's Services	10.50
		Printing	2.49
		Dr. Beal's Expenses	1.65
		Remittance to Gen. Tr.	98.15
		Bank Balance	57.01
	$178.40		$178.40

8. CALGARY CENTRE

Receipts		Disbursements	
Membership Dues	$18.00	Expenses *re* Lectures	$ 1.05
Grant from G. Treas.	8.95	Cheque to Toronto	16.95
		Balance on hand	8.95
	$26.95		$26.95

9. VANCOUVER CENTRE

Receipts		Disbursements	
Balance, Jan. 1, 1935	$ 2.23	Dr. Beals' Expenses	$ 7.53
Fees from Members	58.00	Dr. Petrie's Expenses	10.00
Bank Interest	.35	Exchange	.15
Grant	42.25	Printing	7.47
		Fees to Toronto	72.00
		Balance, Dec. 31, 1935	5.68
	$102.83		$102.83

10. VICTORIA CENTRE

Receipts		Disbursements	
Balance from 1934	$ 2.92	Rent Y.W.C.A.	$ 22.50
Members' Dues	191.00	Printing and Multg.	18.55
Grant from Toronto	103.50	Postage	7.86
Summer Course	28.60	Exchange	.65
Bank Interest	1.35	Flowers to Sick	1.35
Sundries	1.00	Express	.90
		Summer Course	8.54
		Sundries	.70
		Dues to Toronto:	
		1934	181.00
		1935 a/c	50.00
		Grant Tel. Making Section	11.00
		Balance	24.32
	$328.37		$328.37

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

A Bright Fireball

A brilliant fireball of a magnitude equalling Venus at her brightest was observed by Dr. J. F. Heard at the Dunlap Observatory at 9.20 p.m. on February 12. It appeared to the east in the constellation Leo and was described as yellow in colour with a short tail about one degree in length. The writer will be glad to receive any additional observations of this object.

The Importance of Meteor Photographs Taken with a Rotating Shutter

A direct photograph of the average meteor appears as a straight, bright streak which falls off in intensity towards either end of the path. If, however, a rotating shutter is mounted in front of the camera so that it covers the lens several times a second the photographic trail will be cut into segments. Obviously, if the shutter's frequency of rotation is known, the apparent angular velocity of the meteor may be at once computed, and this can be translated into true geocentric velocity where there is a simultaneous observation from a second station.

The late Professor Elkin of Yale was one of the first to use this method successfully in 1899 and since then a number of additional meteor photographs of this type have been secured. The very accurate velocity measures made possible in this way are of the highest value, especially if the photographic trail is long enough to exhibit a definite deceleration. There is, however, a less evident but equally important investigation for which these photographs may be used.

It is a well-known fact that meteors often leave a faintly luminous train visible for some seconds or even minutes after the meteor has disappeared. There is good reason to believe that every meteor is accompanied by such a persistent train of greater or less duration but where it remains for less than half a second it is almost impossible, in visual observations, to untangle the true persistent train

from the effect of the persistence of vision. An ordinary direct meteor photograph is of no help in this case. If a rotating shutter is used, however, at least a partial solution of the problem is possible.

As a first approximation it is customary to think of a meteor as a rapidly moving point of light. But the presence of the persistent train shows us that this is not strictly true and that there is a certain amount of residual luminosity extending behind the effective nucleus of the meteor. The problem is to determine, as nearly as possible, the instantaneous intensity distribution along the path of the meteor. The effect this will have on a photograph

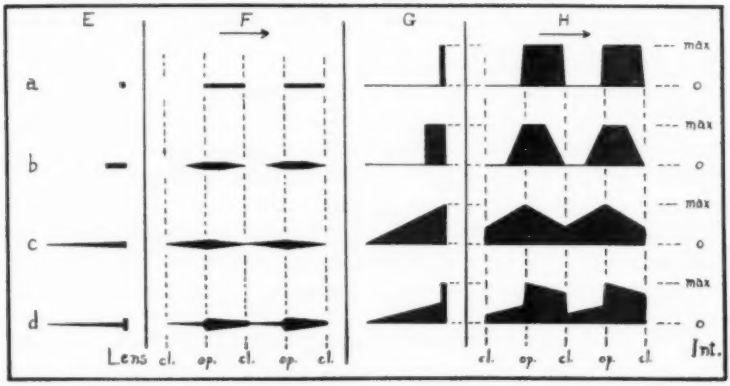

FIG. 1—The effect of the instantaneous luminosity distribution in a meteor on rotating shutter photographs.

taken with a rotating shutter may best be seen with the aid of a diagram. Let us suppose for simplicity of discussion that the lens of the camera is covered and uncovered instantaneously by the shutter. In column E of figure 1 are indicated four hypothetical distributions of luminosity along the meteor's path. Each one of these represents the conditions at any one instant of time. To visualize what will be recorded on the photographic plate we must think of each of these figures as moving horizontally to the right while the camera lens is alternately opened and closed. The results to be expected are plotted in column F. These are found by adding

up all the intensities for each part of the path for each instant the lens is open. The lens is considered to be closed and opened when the head of the meteor reaches the positions indicated by the vertical lines marked cl. and op. respectively. Columns G and H illustrate the same features except that here relative intensities are plotted as heights above a zero line. All plots in the figure are qualitative only and are in no way meant to be quantitative.

It is seen that a simple point meteor, such as type *a*, will give a trail broken into definite segments while a meteor like type *c* will produce a continuous trail which varies regularly in intensity. The greater the length of path over which the instantaneous luminosity is distributed, the more will the effect of the rotating shutter be masked. A meteor with a marked nucleus and a faint train falling off in intensity with distance from this nucleus, may be considered as a combination of types *a* and *c* and is represented in the figure by type *d*. Of the four types of meteors illustrated type *d* probably corresponds most nearly to the actual case. It is likely, however, that the ratio of the luminosity of the nucleus to that of the train is much higher than indicated in the figure. It must also be remembered that the curves plotted in the figure will be modified by the fact that the shutter takes a finite time to cover and uncover the lens and this effect must be taken into full account in the reduction. An even more detailed analysis could be carried out with a three-vane shutter which would give successive exposures whose lengths were in the ratios 1:2:4.

There is no doubt that careful photometry of meteor photographs taken with a rotating shutter will tell us much concerning the nature of meteors and their trains. At the very least, an upper limit can be set to the intensity of the train immediately behind the meteor and with good luck something can be learned concerning the distribution of intensity in this train. All that has been said concerning direct photography applies, with even greater force, to spectrophotography. We have at the present time no accurate knowledge of the spectra of persistent meteor trains. It is to be hoped that all meteor photographers will, where possible, equip their cameras with rotating shutters. These should preferably be operated by synchronous motors since with this type of drive there is no doubt about the speed of rotation.

THE EFFECT OF OBSERVING CONDITIONS ON METEOR RATES

Every meteor observer must recognize that certain conditions greatly influence the numbers of meteors that can be seen from any one station. If the hourly rates of the meteors observed are to be at all significant one must evaluate the observing conditions as accurately as possible. Any system devised for this purpose should be simple and also fairly flexible, leaving room for the judgment of the observer. The writer would suggest, to those reporting meteor counts to this JOURNAL, a system somewhat similar to that used by the American Meteor Society where the integral numbers from 1 to 10 are used, the latter figure denoting perfect conditions.

Apart from the number of observers and the actual rate at which meteors enter our atmosphere there are three chief factors which will influence the number of meteors seen. These are the moon, clouds or haze, and obstructions such as trees and buildings which may hide some of the sky. If there is complete absence of the moon and an unobstructed view of a cloudless sky the observations should be rated 10. The presence of a full moon but no clouds or haze cuts this down to 5. A quarter moon in an otherwise clear sky should be given the rating 8 unless the observer is covering the region of the sky occupied by the moon when 7 is probably more appropriate. If half the observer's field of view is obscured by clouds or if the whole field is obscured for approximately half the time the above factors should be divided by two and rounded off to the nearest integer. A similar adjustment may be made for greater or less obscuration. Haze generally means that from one quarter to one half the meteors otherwise seen are missed and so the observing factor must be reduced by 25 to 50 per cent. of its value.

Finally, after due allowance has been made for moon, clouds, and haze the resulting factor must be further corrected for trees or buildings which may hide part of the field of view. If each observer has a clear field of view 80 to 90 degrees in diameter no correction need be made for buildings or trees as this is the largest area one observer can watch efficiently. It is only where the actual field of view is partially blocked that the observing factor must be reduced accordingly. If a group consists of more than one observer each is supposed to take a different field till the visible hemisphere of sky is covered. P. M. M.

REVIEW OF PUBLICATIONS

Observations of Long Period Variables. Magnitudes and Coordinates of Comparison Stars Made with the 26-inch Refractor. S. A. Mitchell, H. L. Alden, and others. Publications of the Leander McCormick Observatory, University of Virginia, vol. VI, pp. 306, 1935.

It is with great satisfaction that we view the appearance of this important publication on variable stars, which summarizes the work done on long-period variables at one observatory over a period of thirty years, and sets the magnitude standards for variable star observation all over the world. The publication is in two parts. The first part gives tables of 15,284 observations of long-period variables made at the Leander McCormick Observatory from 1902-1933. It should be pointed out of what unusual value these observations are, as they comprise in large measure visual observations of the variables around the time of *minimum*, a thing which few variable star observers have the equipment to accomplish. Accompanying the table is an interesting discussion of the progress of variable star observing, and in particular the difficulties of determining reliable magnitudes.

The second part of the volume, by S. A. Mitchell, gives the adopted magnitudes of 6,284 comparions stars in 350 fields of long-period variables, as determined by accurate photometric measures at the same observatory. Accurate magnitudes (frequently extending into the fifteenth magnitude) are now available, reaching to comparison stars half a magnitude fainter than the variable at minimum. These magnitudes have been formally adopted by the American Association of Variable Star Observers on its blueprint charts. And at the International Astronomical Union in 1932 the magnitudes used by the A.A.V.S.O. were adopted also by the British and French variable star associations. As the magnitudes of any given sequence were determined differentially from the bright stars, the writer points out that a zero point error in the magnitude scale still exists in some regions. He expects to remedy

this in the future, but does not consider it a serious defect as long as observers use the same magnitude sequence in any given field.

H. B. S. H.

Worlds Without End, by H. Spencer Jones. The English Universities Press, London, 1935; the Musson Book Company, Ltd., Toronto. Price, $1.50.

This excellent book has been reviewed at length in the January, 1936, number of this JOURNAL (p. 23). The purpose of this note is to call the attention of Canadian readers to the fact that the English edition of the book is now obtainable, at a price of $1.50 from the Musson Book Company, of Toronto.

Cycles of Reduced Ideals in Quadratic Fields, by E. L. Ince Office of the British Association Committee for the Calculation of Mathematical Tables, London, 1934.

One of the greatest advances in the theory of numbers made during the 19th century was the creation of the theory of algebraic numbers. When one considers the numbers of an algebraic field, for instance in the quadratic case all the numbers $a+b\sqrt{m}$, a and b being arbitrary rational numbers and m a fixed integer, and tries to define the greatest common divisor of such numbers and build up a theory analogous to the elementary theory of numbers, difficulties arise which had not been suspected by the mathematicians of the preceding centuries. These difficulties, however, can be overcome by adding new "imaginary" elements, the "ideals", to the numbers of the field. In the domain thus extended the same laws as in elementary theory of numbers hold. One of the new notions made necessary by this point of view is the concept of the class of ideals. Two ideals are said to be equivalent if their quotient can be represented by an ordinary number of the field. Thus all the ideals are distributed in a finite number of classes of equivalent ones.

The most important and best studied case is that of a quadratic field $a+b\sqrt{m}$, mentioned above. Here it is possible to actually obtain the classes of ideals by selecting particular reduced ideals in every class. These reduced ideals of a class are connected in a simple manner thereby forming a cycle.

Dr. E. L. Ince has computed all the cycles of reduced ideals in a quadratic field $a+b\sqrt{m}$ where m is a positive integer less than 2025 not having a squared factor. Furthermore in his tables the distribution of classes of ideals into genera is described and the fundamental units of all these quadratic fields are given.

These tables will be of great use to every mathematician who wishes to apply the general methods to interesting particular cases. Further, although so much work has been done in this field, still there are very important questions concerning which we know little to-day. It is to be hoped that the material provided in these new tables will facilitate the work of research. The tables were published on behalf of the British Association Committee for the Calculation of Mathematical Tables, the publication having been made possible by the bequest of Lt.-Col. A. J. C. Cunningham.

RICHARD BRAUER.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Occultations for Amateurs

In the Preface to the Observer's Handbook for 1936 is a reference to the publication of the prediction of occultations, and a request is made for suggestions. Some communications have been received regarding this matter and it is still under consideration. It may be remarked here, however, that among the great amount of information regarding occultations given in the *American Ephemeris* there are precise calculations for four "standard stations" in the United States. These are: Washington, D.C.; Long. $72\frac{1}{2}°$, Lat. $42\frac{1}{2}°$ (near Keene, N.H.); Long. 91°, Lat. 40° (near Quincy, Ill.); Long. 120°, Lat. 36° (in central California). In the tables coefficients are supplied which enable one to compute the occultations for any point within about 300 miles of the above stations.

In the British *Nautical Almanac* for 1937 will be found tables giving the times for occultations visible at Montreal and at Toronto, together with coefficients permitting the computations to be extended to places covering most of Quebec and Ontario, and beginning with 1939 this publication will include the occultations for Vancouver and Calgary.

C. A. C.

MEETINGS OF THE SOCIETY

AT EDMONTON

January 10, 1935.—Mr. C. G. Wates spoke on "The Construction of a Home-made Telescope." Mr. Wates has built a 9-inch reflecting telescope which is mounted in an observation hut in a commanding position on the bank of the Saskatchewan River. An excellent photograph of this instrument is reproduced on the cover of the October issue of the *Scientific American*. Mr. Wates described in detail the care and precautions necessary in grinding and silvering a satisfactory mirror, and expressed his intention of embarking on the construction of a 12-inch instrument with improved mounting.

February 14.—Dr. J. W. Campbell discussed "The Motions of the Earth." Dr. Campbell described the principal phenomena resulting from the earth's diurnal and annual motions. He illustrated with a gyroscopic model the phenomena of precession of the equinoxes and nutation of the celestial pole, and mentioned the possible connection of the advance of perihelion with the glacial periods in geological history.

March 14.—Prof. E. S. Keeping's subject was "Weighing the Earth." Mr. Keeping described some of the earlier determinations of the mass of the earth and illustrated by a model the principle of the Cavendish experiment. The great technical difficulties overcome in the more modern and exact determinations were briefly discussed.

April 11.—Mr. W. O. Coulman spoke on "The Tides." Mr. Coulman illustrated by diagrams the action of the sun and moon in producing tides. He emphasized the importance of tide-prediction in navigation, and referred to the unusual tides such as occur in the Bay of Fundy.

May 16.—Dr. C. S. Beals, of the Dominion Astrophysical Observatory, spoke on "What is a Star." Dr. Beals kindly consented to address the Centre on his way east. He spoke of primitive ideas on the nature of the stars, as contrasted with the tremendous growth of our knowledge in recent years, which is due to greatly improved physical apparatus and to the brilliant application of the quantum theory and the theory of relativity to the problem of conditions in the interior of a star. The lecture was illustrated by a number of lantern slides.

October 10.—Dr. R. L. Rutherford had as his subject, "The Structure of the Earth." Dr. Rutherford discussed the extent of our knowledge of the earth's crust and of the interior, the indications afforded by seismology, and the evidence for theories of isostasy and continental drift.

November 14.—Prof. L. H. Nichols discussed "The Earth's Atmosphere." Mr. Nichols illustrated by experiments the principle of the barometer and of Galileo's thermometer. He dealt with various phenomena connected with atmospheric refraction, including twinkling of the stars, mirages, "looming," and the "fata morgana." He also illustrated experimentally the production of

blue sky and red sunset glow by the scattering of sunlight, and spoke briefly on the weather and the use of meteorological charts.

December 12, 1935.—Mr. W. H. Poole addressed the meeting on "Galileo." Mr. Poole gave a vivid historical account of the life of the great Italian astronomer, of his sincerity and love of truth, and of his long and bitter struggle with the forces of tradition and authority.

This meeting was the annual dinner meeting, held in the Corona Hotel, at which 42 members and friends were present. Officers for the year 1936 were elected as follows:

Hon. President: Dr. J. W. Campbell; *President:* Mr. F. S. Simpson.

Vice-President: Mr. J. G. Taylor; *Treasurer:* Mr. E. N. Higinbotham.

Secretary: Mr. E. S. Keeping; *Social Convener:* Miss M. Hamilton.

Council: Mr. John Blue, Miss M. O. Buchanan, Mr. R. Chambers, Dr. E. H. Gowan (*ex officio*).

E. S. KEEPING, *Secretary.*

AT VANCOUVER

December 10, 1935.—Annual meeting. The following officers and members of council were elected for 1936:

Hon. President: Dean D. Buchanan, Ph.D.; *President:* C. A. McDonald.

1st Vice-President: H. P. Newton; *2nd Vice-President:* Mrs. Laura Anderson.

Secretary: J. W. Moore, 2505 W-10th Ave., Vancouver; *Treasurer:* A. Outram.

Councillors: Seto More, M. A. McGrath, D. L. Shaw, G. E. Frostrup, J. C. Jorgenson, J. W. Pickin, H. A. Pitman, S. Richmond, J. Donald.

C. A. MCDONALD, *Secretary.*

AT VICTORIA

December 11, 1935.—The annual meeting was held in the Y.W.C.A. Parlors. President Tingley was in the chair. The minutes of the last annual meeting were read and approved. Ballots for the election of officers for the ensuing year were called for, and while the scrutineers, Messrs. Haley and Grist determined the result, President Tingley called on the Secretary-Treasurer, Mr. Gordon Shaw, for his report. The finances of the Society were notably improving while membership continued to increase. The Summer Course had been a decided success in attendance, interest and publicity for the Society.

A short report on the Telescope Making Section was presented by Mr. W. R. Hobday, regular meetings were being held and four new mirrors were being started.

President Tingley in his report pointed out that the Victoria Centre was celebrating its 21st birthday and was the second oldest centre in Canada. He referred to the interesting syllabus of addresses given during the year. He referred to the Summer Course as having been instructive and helpful. It had had an average attendance of 68. He also alluded to the attempt of the two young brothers Leonard and Ronald Hopkins to cast a fifteen inch glass disc for a telescope mirrir which might have proven a success but for rainy weather.

Outstanding astronomical events of the year were touched upon, including the opening of the David Dunlap Observatory with its 74 inch mirror, in Toronto.

Announcement by the scrutineers of the elected officers was then presented with the following results:

Hon. President: H. Boyd Brydon.

President: Lt. Comdr. H. R. Tingley; *Vice-President:* Robert Peters.

Secretary-Treasurer: Gordon Shaw; *Librarian:* Mira Oliphant.

Council: A. I. Deacon, W. R. Hobday, L. Hopkins, Andrew McKellar, Ph.D., R. M. Petrie, Ph.D.

Following the announcement of the newly elected officers, the Hopkins brothers gave some thrilling experiments with high voltage electricity, some very spectacular and beautiful effects being obtained. Comdr. Tingley also demonstrated with a model the motions of the earth and displayed a new type of sun dial. This was followed by a musical programme including songs by Miss Phyllis Deaville and Mr. K. Simmons, and selections by a string trio comprising Mr. A. Darimont, violinist, Gordon Shaw, cellist and Miss Barbara Fraser, pianist. Refreshments were served.

GORDON SHAW, *Secretary.*

OFFICERS ELECTED AT OTHER CENTRES

At the Centres other than those given above the officers chosen for 1936 were as follows:

TORONTO CENTRE

Hon. Chairman: Dr. C. A. Chant.

Chairman: A. R. Hassard, K.C.; *Vice-Chairman:* E. J. A. Kennedy.

Secretary: S. C. Brown, 22 Kings Lynn Rd., Etobicoke, Ont.

Recorder: Miss F. S. Patterson, B.A.; *Treasurer:* J. E. Maybee.

Council: Dr. D. S. Ainslie, Dr. L. Gilchrist, F. L. Harvey, Dr. F. S. Hogg, J. H. Horning, T. H. Mason, Dr. P. M. Millman, Rev. C. H. Shortt, Dr. R. K Young, and the past Chairmen.

OTTAWA CENTRE

Hon. President: R. Glenn Madill; *President:* A. H. Miller.

1st Vice-President: J. McLeish; *2nd Vice-President:* Miss M. B. Burland.

Secretary: M. M. Thomson, Dominion Observatory; *Treasurer:* A. W. Grant.

Council: Dr. A. Willard Turner, Dr. E. A. Hodgson, W. F. Matley, W. J. Sykes, Karl Buckthought, and the past Presidents.

MONTREAL CENTRE

Hon. President: Mgr. C. P. Choquette; *President:* Geo. R. Lighthall.

1st Vice-President: Dr. Julian C. Smith; *2nd Vice-President:* F. De Kinder.

Secretary-Treasurer: Dr. A. V. Douglas, Physics Building, McGill University.

Council: Dr. A. N. Shaw, Col. W. E. Lyman, G. Harper Hall, Dr. L. V. King, Dr. C. C. Birchard, O. A. Ferrier, H. F. Hall, E. R. Paterson, J. A. Reid.

LONDON CENTRE

Hon. President: Dr. H. R. Kingston.
President: Major E. H. Anundson; *Vice-President:* D. M. Hennigar.
Secretary: Dr. G. R. Magee, 427 William St.; *Treasurer:* Dr. H. S. Wismer.
Council: Miss S. Livingstone, Miss M. Tory, T. C. Benson, Rev. R. G. Bowen, L. G. Planques.

WINNIPEG CENTRE

Hon. President: Dr. J. S. Plaskett; *President:* A. V. Pigott.
1st Vice-President: W. H. Darracott; *2nd Vice-President:* J. H. Kolb.
Secretary: Miss K. St. John, Ste. 4, Rideau Hall; *Treasurer:* R. D. Colquett.
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